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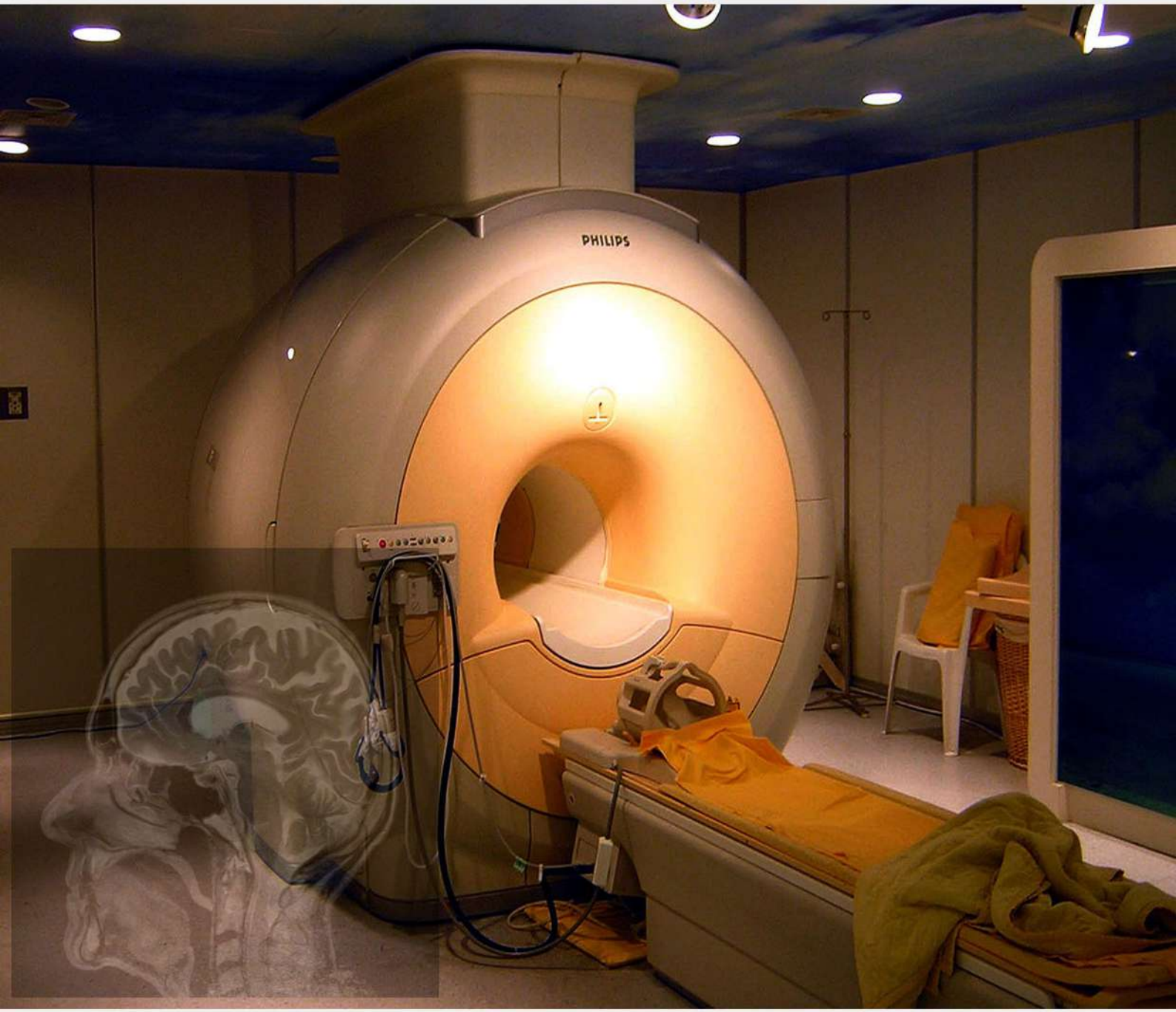

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Original Research

Uptake of the BI-RADS Ultrasound Characterization of Breast Masses: Perceptions among Staff at Mulago National Referral Hospital, Uganda

Alex Onono, BSc; Aloysius Gonzaga Mubuuke, PhD*

Department of Radiology, School of Medicine, Makerere University, Kampala, Uganda

Corresponding author
Aloysius Gonzaga Mubuuke, PhD
Department of Radiology, School of Medicine, College of Health Sciences, Makerere University, P. O. Box 7072, Kampala, Uganda; Tel. +256772616788;
E-mail: gmubuuke@gmail.com

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ABSTRACT

Introduction
The Breast Imaging-Reporting and Data System (BI-RADS) is a classification system aimed at standardizing risk assessment during breast ultrasound to ensure patient safety. BI-RADS is currently used in Uganda so as to standardize breast ultrasound reporting and enhance patient management.

Objective
This study aimed at exploring staff perceptions towards the use of the BI-RADS ultrasound characterization of breast masses.

Methodology
It was an exploratory qualitative study that involved staff who perform breast ultrasound at Mulago Hospital in Uganda. Focus group discussions and individual interviews were conducted.

Findings
All staff used the BI-RADS system, however, some of them had a negative attitude towards BI-RADS. The three major themes that emerged were: standardization of breast ultrasound reporting for patient safety; need for more Continuous Professional Development (CPD) and challenges with the BI-RADS system.

Conclusion
The study demonstrated that the staff generally had positive perceptions and attitude of the BI-RADS system and felt that it was an efficient system for ensuring patient safety and further reduce mortality from breast cancer.

Keywords
Breast imaging-reporting and data system (BI-RADS); Breast; Ultrasound; Staff perceptions.

INTRODUCTION

Breast cancer is the third commonest cancer in women in Uganda after Kaposi's sarcoma and cervical cancer.[1-3] Five year survival rate is 56%.[1] Several studies have reported that breast cancer is the most common cancer that compromises patient safety and resulting in cancer deaths in women thus remaining a world concern.[4-10] For example in Brazil, breast cancer is the leading cause of cancer deaths among women.[11] Among Turkish women, breast cancer represents 24.1% of all cancers and is the second prime cause of cancer-related deaths.

It has been reported that by 2020, 70% of the 15 million new annual cancer cases will be in developing countries.[12] In South Africa breast cancer is the most common cancer in women. The lifetime risk of developing breast cancer is 1 in 26-women across all population groups. Annually more than 3000-women die from breast cancer in South Africa. More than 60% of women present with locally advanced breast cancer. It has been speculated that the lack of an early cancer detection program is responsible for the majority of women presenting at a late, symptomatic stage when cure is impossible.[12]

Primary randomized controlled trials have shown the significance of mammography in the early diagnosis of breast cancer in asymptomatic women and it has been effective in decreasing mortality especially in women aged 50-69-years with reductions of 20% to 35%.[13,14] However, for the women who know about mammography, the costs involved are still very high which prevents them from going for it.[15] Besides the economic issues, other difficulties of mammography include the fear of irradiation that can potentially compromise patient safety due to harmful effects of radiation.[16] There is a wealth of literature reporting women's adherence to mammography including their knowledge, behavior and beliefs about breast cancer, knowledge of risk factors, attitudes and mammography.[4] There have been some improvements in the encouragement of women to have mammograms. Nevertheless, mammography remains underutilized by women although it can be effective in early detection of breast cancer.

The primary factors that increase the risk of breast cancer in women include family the history of breast cancer, certain inherited genetic mutations and biopsy-confirmed hyperplasia.[17] Other factors that increase breast cancer risks include a long menstrual history, obesity after menopause, recent use of oral contraceptives, postmenopausal hormone therapy, nulliparity or having the first child after the age of 30, ethnicity characteristics, exposure to radiation, or consumption of one or more alcoholic beverages per day.[1] Factors that decrease breast cancer risks include breastfeeding, physical activity, and the maintenance of healthy body weight.[18] Unfortunately, many women lack access to all this information. Mammography, clinical breast examination (CBE) and breast self-examination (BSE) are the secondary preventive methods used for investigation in the early detection of breast cancer.[19] Cancer detection investigations, therefore, play a pivotal role in reducing breast cancer related mortalities.

The American Cancer Society (ACS) recommends CBE and mammography in the early detection of breast cancer.[20] According to ACS recommendations, women should know how their breasts normally feel and report any breast changes promptly to their health care providers. BSE is an option for women starting from the early 20 s.[20] ACS no longer recommends BSE as there is reliable data that breast cancer detection through BSE does not increase the survival rate.[20] However, in a developing and resource-constrained country like Uganda, BSE is an important viable optional substitute, where access to CBE and most importantly mammography is extremely difficult and might still detect breast cancer early enough for treatment which can be offered to prolong women´s lives and reduce suffering. Women in their 20 s and 30 s should have a CBE as part of a periodic health examination by health professionals preferably every 3-years. After the age of 40, women should have a CBE and a mammogram every year, as recommended by the ACS.[21] Annual mammography is considered the most valuable tool for detecting breast cancer in the earliest possible stages, before cancer has metastasized and when interventions are most effective, least invasive and debilitating. The decline in breast cancer mortality has been largely attributed to regular mammography investigations.[21]

Since mammography, which is the gold standard imaging modality for screening and diagnosis is expensive and inaccessible to most women especially in developing countries, the use of breast ultrasound and breast imaging reporting and data system (BI-RADS) classification has been widely advocated for. The BI-RADS system is an internationally recognized system of characterizing and classifying breast masses as seen at ultrasound, mammography and magnetic resonance imaging (MRI),[22-24] and it is used by imaging professionals to standardizing their reporting and ease communication of imaging findings to the referring clinicians. However, this study focused on BI-RADS use in breast ultrasound. The BI-RADS system of characterizing breast masses at ultrasound investigations is comprised of seven categories namely: BI-RADS 0, 1, 2, 3, 4, 5 and 6. These are summarized in Table 1.

Table 1. *BI-RADS Breast Ultrasound Categories*

BI-RADS Category	Summary Description
BI-RADS 0	Needs additional imaging
BI-RADS 1	Normal
BI-RADS 2	Benign
BI-RADS 3	Probably benign
BI-RADS 4	Suspicious
BI-RADS 5	Highly suspicious
BI-RADS 6	Known breast malignancy

The BI-RADS system has been reported to be very useful in the prompt management of women with breast masses.[25] In the absence of routine mammography screening services, breast ultrasound using BI-RADS classification can be an effective way of evaluating palpable breast masses and an appropriate management recommendation formulated early enough when treatment is still possible.[21] The BI-RADS classification is also useful in standardizing the communication of breast ultrasound findings.[18]

In Uganda, the BI-RADS system of characterizing breast masses at ultrasound have been adopted in practice. However, the perceptions of staff towards this standardized system of reporting breast ultrasound findings have not been previously explored in Uganda, hence this study aimed at exploring perceptions of radiology staff regarding the use of the BI-RADS ultrasound system.

MATERIALS AND METHODS

Study Design

This was an exploratory qualitative study conducted among staff that performs breast ultrasound in the radiology department of Mulago National Referral Hospital in Uganda.

Participants and Sampling

Purposeful consecutive sampling was used to select 4 radiologists and 18 sonographers who had received training in the use of BI-RADS system of categorizing breast masses.

Data Collection and Analysis

Data was collected using both focus group discussions and individual interviews. Three focus group discussions were conducted with the sonographers, each group having 6 participants and 4 individual interviews were conducted with the radiologists. The participant responses were audio-recorded and later transcribed. Thematic analysis was employed to generate codes, categories and the eventual themes that finally emerged from the study.

Ethical considerations

The study received approval from the Mulago Hospital Research and Ethics Committee (Protocol No: MHREC 1545). Informed consent was obtained from all the participants prior to conducting the focus groups and interviews. The participants were also assured of the anonymity and confidentiality of their responses and no names were to be tagged to any response. Participants were also informed that they were free to withdraw from the study at any one time.

FINDINGS

Four (4) radiologists, eighteen (18) sonographers participated in the study. Eight of the participants were female and the rest were male. All these staffs that participated are currently working in the ultrasound units of the radiology department in Mulago hospital had received some training in the use of the BI-RADS breast ultrasound reporting system. The study resulted in three major themes namely: Standardization of breast ultrasound reporting: a precursor for patient safety; Need for more continuous professional development (CPD) and Challenges with the BI-RADS system.

Standardization of Breast Ultrasound Reporting: A Precursor for Patient Safety

All the staff reported that the BI-RADS breast ultrasound system facilitates the classification of breast masses according to international standards and ensures that all staff use similar guidelines and characteristics to assess breast masses. This, in turn, ensures the timely intervention of management procedures for women with especially a suspicious breast mass when therapeutic options are still possible. Consequently, the BI-RADS system ensures patient safety. The following responses illustrate this theme as reported by the participants.

"Previously some women with breast masses would succumb to breast cancer simply because they were not prioritized as urgent cases requiring timely intervention, however with the BI-RADS system, many of these urgent cases can now be identified after scanning and attended to quickly which ensures their safety…….many of them have survived death because the BI-RADS ultrasound report helped Clinicians to give them priority."

"With this BI-RADS classification, I have realized how patient safety is now important. Previously, we just used to write presence of breast masses, however with BI-RADS, one can prioritize so that the safety of those women with highly suspicious breast masses is ensured first…..even if they are to die eventually, their lives are prolonged and quality added".

The above two responses generally reflect what all the participants alluded to that the BI-RADS system has facilitated the prioritization of women with highly suspicious breast lesions to ensure their safety and improve their quality of life.

Need for more Continuous Professional Development

The second theme spoke to the need for CPD regarding the BI-RADS breast ultrasound reporting system. This was a common thread throughout all the responses. The staff were pointing to the fact that despite using BI-RADS and its obvious benefits in maximizing patient safety, there was still a need to re-train staff periodically about this system. This argument can be seen through the following representative quotations from the participants:

"The BI-RADS system has useful benefits especially in as far as prioritizing women that need urgent management attention to ensure their safety. However, we still need continued training with this system because I have realized that different people are still mixing up the BI-RADS categories which sometimes causes anxiety and unnecessary worry among patients and clinicians……more continuous training is thus needed so that we all speak the same language."

"Much as BI-RADS was meant to standardize the reporting of breast masses, there are still variations in how we write our reports. For example, some people still view ultrasound features differently and ignore some of them. The solution is to have periodic sessions where we remind ourselves of the key features for each BI-RADS category and this will ensure that the safety of women that need urgent attention is maximized."

From the above responses, one can observe that despite BI-RADS being aimed at standardizing breast ultrasound reporting, there are still variations in how staff categorizes the breast masses, which would compromise on patient safety as well, hence the need for continuous training.

However, the CPD should not only be limited to the side of the breast imaging experts. There is a need to sensitize other clinicians about the importance of BI-RADS as a system for standardizing breast ultrasound reporting and ensuring patient safety. Ignorance of the BI-RADS system by other professionals that might compromise patient safety can be seen to resonate through the response below:

"Some physicians send back breast ultrasound reports just because they haven't understood what it means by BI-RADS 1, 2, 3, etc."….just concluding with a BI-RADS classification does not make the physicians know how the mass really is……therefore BI-RADS seems to be only a well understood language by radiology professionals only"

Challenges with the BI-RADS System

The last dominant theme that resonated through the responses related to challenges faced with using the BI-RADS breast ultrasound reporting system. Most of these responses were in relation

to a negative attitude by some of the imaging staff towards this system because this standardized way limits their descriptive reporting that was previously used. This can be observed in the following response:

"This BI-RADS system though good, limits my ability to present to the doctor what exactly I have seen. Previously, we had liberty to write as much as we wanted to include everything we had seen…..but now we are limited. At least the reporting templates should have space for us to still write some notes."

The other challenge observed through the responses was the fact that the BI-RADS standardized system is not used all the time within the department. This results into situations where some reports are structured according to the BI-RADS system while others are not, which might also compromise quality and thus affect the safety of women with breast masses. The following response was common:

"Sometimes we are overwhelmed by the big number of women to scan and going through the BI-RADS template consumes more time….so for me I simply write a short descriptive report to the referring doctor."

DISCUSSION

The purpose of this study was to explore staff perceptions regarding the use of the BI-RADS system in reporting breast masses on ultrasound as a way of ensuring patient safety among women. Findings from the study generally demonstrated positive perceptions of the staff towards the BI-RADS system of reporting breast masses. There seemed to be a general agreement that the BI-RADS system facilitates the standardization of reporting features of breast masses which eventually facilitates timely patient management. This finding is in resonance with previous studies which also report that the BI-RADS system of reporting breast ultrasound scans provides a more standardized way of ensuring that women with suspicious breast masses are prioritized and attended to first.[5] However, this study presents an alternative angle of thought in terms of patient safety. By categorizing breast masses according to the BI-RADS system, the health workers are basically bringing to the fore the safety of patients, in this context the women with highly suspicious breast masses, who would then be managed first to prevent a possible spread of a cancer or at least to improve the quality of life of these patients. This notion of relating the BI-RADS system to the concept of patient safety resonated through the participant responses. Without the BI-RADS system, many women with potential cancerous breast masses would probably not be prioritized, thus compromising their safety. Therefore, the concept of standardizing the breast ultrasound reporting should be viewed as a way of optimizing patient safety in which the most at risk women are attended to first. This is particularly important in this era of increasing mortality due to breast cancer.[16]

Despite the fact that participants in this study generally had positive perceptions of the BI-RADS system, the need for CPD specifically focusing on BI-RADS was evident, a finding that is in agreement with previous studies.[14] The fact that participants in this study had previous training in the BI-RADS system, but still recognized the need for periodic CPD sessions should not be ignored. It has been reported that despite there being specific features of breast masses at ultrasound within the various BI-RADS categories, many imaging professionals still find challenges characterizing these masses.[11-16] Findings from this study alluded to this reported literature as well. Breast ultrasound is a real-time examination and the interpretation of the features of breast masses solely depends on the individual doing the breast scanning at that particular time. As a result, well defined breast masses can be interpreted as ill-defined masses simply due to a poor visualization of the mass or poor technique on the side of the imaging professional. This can result into unnecessary anxiety to patients and unnecessary biopsies of benign masses, while delaying the management of potential cancerous masses at the same time. This therefore compromises patient safety, especially those women with missed suspicious breast lesions. Therefore, the need to continually train staff in the key characteristic feature of the various BI-RADS categories needs to be carried out.

In relation to CPD sessions, the idea that clinicians who refer these women for ultrasound should also be included in the CPD package is very important. From this study, clinicians seemed to send back several BI-RADS reports simply because they could not understand this reporting system. Subsequently, patient management gets delayed which further compromises patient safety. Therefore, even other health workers that manage women with breast symptoms need to be included within the CPD package. It is recommended that the radiology departments organize tailored CPD sessions for clinicians within the other departments so that they are educated about the BI-RADS breast ultrasound reporting system. It is only through this way that this system will receive maximum operationalization within the hospitals dealing with breast cancer management.

Although the BI-RADS breast ultrasound reporting system was generally perceived as being good in terms of standardization and ensuring patient safety, the staff who participated in this study sometimes did not follow this system mainly due to its limitation in terms of description as well as large patient numbers. The observation that this structured way of reporting breast ultrasound scans was perceived by staff as limiting the description of the breast report has been reported elsewhere.[13] This is perhaps attributable to the fact that every professional would like to describe as much as possible the ultrasound findings so that the referring clinician can get a true picture of the findings. However, this is perhaps where the challenge lies. Descriptive ultrasound reports with no structure may often lead to non-standardized reporting without a clear management pathway for the patient, which ultimately compromises patient safety. The BI-RADS structured way of reporting ensures that all professionals communicate the same language and clearly alerts the clinician to the next management plan because each BI-RADS category dictates a management plan. We think that perhaps more training in using the BI-RADS system can change this attitude. Similarly, the notion that the BI-RADS structured

reporting may not be applicable due to large patient volumes in this setting is surprising. One would think that writing descriptive reports without following the BI-RADS system would actually be more cumbersome and not applicable in settings with large patient volumes. However, findings from this study are on the contrary to this. The plausible reason as to why participants viewed BI-RADS ultrasound reporting as not applicable due to large patient numbers is not clear-cut. However, we think this could be an attitudinal mind-set because BI-RADS reporting is relatively new in this context. However, more research is needed to explore this observation in more depth. The fact that this was a qualitative study carried out in only a particular setting has its own limitations. This combined with the small participant numbers limits the generalizability of these findings. However, the findings still provide insights that can guide future larger studies across different settings. The fact that participants perceived the BI-RADS breast ultrasound system as an aspect of ensuring patient safety is a strength of this study. We do recommend sustained CPD sessions regarding the BI-RADS system involving not only staff within radiology departments, but also other clinicians that handle breast-related cases.

CONCLUSION

This study has demonstrated that the staff who perform the breast ultrasound scans at Mulago National Referral Hospital generally had good perceptions of the BI-RADS system and actually used it most of the time. This was seen as an aspect of ensuring patient safety, especially those women with suspicious breast masses. The idea of periodic CPD sessions focusing on BI-RADS for both radiology staff as well as other clinicians needs to be put into place.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Retrospective Study

Exploring the Association between Demographic Factors and Breast Cancer Diagnosis at a Holistic Breast Imaging Clinic in Cairo, Egypt

Hanan S. Gewefel, MD, EDBI[1*]; Sophia Michelen, MPH[2]; Bodour Salhia, PhD[3]; Iman Ewais, MSc[4], Mona Fouad, MD, MPH[5,6]; Sejong Bae, PhD[5,6]

[1]*Department of Radiologic Imaging Technology, Misr University for Science and Technology (MUST), Cairo, Egypt*
[2]*London School of Hygiene & Tropical Medicine, London, UK*
[3]*Department of Translational Genomic, University of Southern California, Los Angeles, CA 90089, USA*
[4]*Women and Fetal Imaging (WAFI) Center, Cairo, Egypt*
[5]*Division of Preventive Medicine, School of Medicine, University of Alabama, Birmingham, AL 35294, USA*
[6]*O'Neal Comprehensive Cancer Center, School of Medicine, University of Alabama, Birmingham, AL 35294, USA*

[*]***Corresponding author***
Hanan S. Gewefel, MD, EDBI
Assistant Professor, Faculty of Applied Medical Sciences, Department of Radiologic Imaging Technology, Misr University for Science and Technology (MUST), Cairo, Egypt; E-mail: drhanan@drhananclinic.com

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ABSTRACT

Background

Breast cancer is among the most common cancers affecting women worldwide, including Egypt. Age is a well-known determinant of breast cancer risk; however, more data is needed to better understand the importance of age on incidence of breast cancer in the Middle East. Being overweight or obese are also known risk factors—especially for post-menopausal women–however, these data are not available for women in developing countries.

Purpose

The purpose of this study was to qualitatively explore the association between age, breast density, and demographic factors of breast cancer patients, across a spectrum of radiological breast diagnoses at a large Breast Imaging Clinic in Cairo, Egypt.

Materials and Methods

We explored the association between age, demographic factors, and Breast cancer incidence among 6,711 women undergoing mammographic screening over a consecutive period of 6-years. Data was collected from March 2007 until March 2013 and extracted from an electronic data base system.

Results

A total of 6,711 participants were included in this study. The median age of all patients was 46.1. Mean body mass index (BMI) of 28.5, where 34% of the patients were overweight and 32.4% were obese. Older women were more likely to be obese compared to younger women (38.4% *vs* 18.1%, $p<0.001$). Older females were more likely to have less dense breasts (ACR: A) compared to younger females (18.1% *vs* 8.7%, $p<0.001$). Women older than 40 had a higher confirmed number of breast cancer diagnoses compared with the younger age group (10.7% *vs* 3.5%, $p<0.001$). Women with breast cancer were more obese ($p<0.001$), had denser breasts ($p<0.001$), were post-menopausal ($p=0.002$), and more likely to be Muslim ($p=0.0021$). In the multivariate analysis, aforementioned factors were significant predictors for confirmed diagnosis.

Conclusion

To our knowledge this is the largest study to examine the association of radiological breast assessments on breast cancer incidence, obesity and demographic factors in Egypt. Although data shows the global burden of breast cancer is shifting to the developing world and affecting younger women at alarming rates, our data demonstrated a very low occurrence of breast cancer in both age groups.

Keywords

Breast cancer; Breast radiological diagnoses; Phenotypic variations; Breast imaging-reporting and data system (BI-RADS).

INTRODUCTION

Breast cancer (BC) is a disease with great association link to age, it has been well established that survival is improved significantly if detected and treated early. Delayed diagnosis and management lead to poor survival as a consequence, that creates important public health issue in the Middle East.[1] In the Middle East and Arab population, late diagnosis has been attributed to the, illiteracy rate, lack of knowledge about BC, and to the poor resources to screening programs.[2,3] Analysis of global burden of disease (GBD) 2016 data demonstrated the rising incidence of breast cancer disease in the Arab world.[4] The breast cancer incidence in the Arab region (28/100,000) was lower than the global mean (46/100,000) in 2016.[5] Arab countries with higher sociodemographic index tended to have a higher burden (39/100,000) of breast cancer. The rate of rise is comparable with the global trend and it is predicted to continue to rise if no interventions are implemented.

A great body of literature reviews has estimated that breast cancer accounts for 13-35% of all female cancers in Arab countries. With a clear trend toward earlier age of onset as well as presentation at advanced stages among Arab females,[6] a recent rise of Age-Standardized Incidence Rates (ASR) is also noted. Advanced disease remains very common in Egypt, Tunisia, Saudi Arabia, Syria, Palestinians and others.[7] A few studies have investigated individual demographics along with other factors in Breast Radiological Diagnoses in Arab countries. In this paper we conducted a retrospective study to explore the association between demographic and other factors along with radiological breast diagnoses.

MATERIALS AND METHODS

Study Population

With approval from the institutional review board, 6,711 (Table 1) women undergoing mammographic screening over a consecutive period of 6-years were studied at the Women and Fetal Imaging (WAFI) center in Cairo, Egypt. WAFI is a specialized center for mammography, fetal imaging (3D/4D fetal scan by ultrasound), dual-energy x-ray absorptiometry (DEXA) bone density scan, and Ultrasound. WAFI also provides complementary services, inclusive of medical education and research.

Data was collected from March 2007 until March 2013, having been extracted from an electronic database system. Ages of the participants ranged between 30 to 70-years of age, with a median age of 46.1-years. Body mass index (BMI) was calculated for the participants. Clinical breast examinations were conducted, along with which sonographic and mammographic evaluation, including family history were determined. Breast imaging and reporting data system (BI-RADS) and pathologic biopsy results were taken when obtained, with clinical follow-up and clinical outcomes.

Table 1. *Patient Characteristics of All Patients*

Characteristics n (%)	Age (Years)				
	<40		**≥ 40**		**Total**
	2060	(30.42)	4711	(69.58)	6711
BMI					***p*-value**
Normal	699	(50.87)	885	(27.05)	<0.0001
Overweight	427	(31.08)	1132	(34.60)	
Obese	248	(18.05)	1255	(38.36)	
Religion					
Muslim	1840	(89.32)	3851	(81.74)	<0.0001
Christian	220	(10.68)	860	(18.26)	
BIRAD					<0.0001
Negative/Normal	846	(41.07)	1489	(31.61)	
Benign	839	(40.73)	1941	(41.20)	
Probably Benign	309	(15.00)	771	(16.37)	
Probably Malignant	29	(1.41)	177	(3.76)	
Malignant	37	(1.80)	333	(7.07)	
ACR					
ACR1	99	(8.86)	786	(18.04)	<0.0001
ACR2	567	(50.72)	2341	(53.74)	
ACR3	349	(31.22)	1016	(23.32)	
ACR4	103	(9.21)	213	(4.89)	
Family History					
Breast CA	593	(28.79)	1433	(30.42)	0.0434
Other CA	25	(1.21)	89	(1.89)	
NA	1442	(70.00)	3189	(67.69)	
Menopausal					
Pre	1495	(97.27)	1369	(42.42)	<0.0001
Peri	19	(1.24)	182	(5.64)	
Post	23	(1.5)	1676	(51.94)	
Breast Feeding					
Yes	690	(86.25)	2007	(83.80)	0.0981
No	110	(13.75)	388	(16.20)	

BMI: Body mass index; ACR: American college of radiology. Total may not add up to 6,771 due to missing values.

Imaging Technique and Interpretation

For the screening and diagnostic mammography and the ultrasound examination, practice guidelines of the American College of Radiology was followed. Women under 40-years of age were first screened with ultrasound. Mammography examinations were determined through presentation of clinical symptoms or through sonographic findings. While the clinical outcome may have indicated the type of screening, the physician had discretion to modify procedure for the patient as the radiologists (both of whom had 10 to 15-years of experience in breast imaging) were the ones to provide decision as to the need to further mammographic examination.

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Irrelevant of age, mammographic and sonographic findings of all the patients were described using BI-RADS lexicon whereby the final BI-RADS category was reported at the end of each examination. The BI-RADS categories for the patient outcomes were as follows.[8,9]

BI-RADS category 1: Negative (essentially 0% likelihood of cancer)
BI-RADS category 2: Benign (essentially 0% likelihood of cancer)
BI-RADS category 3: Probably Benign (>0% but ≤2% likelihood of cancer), short tirm follow-up is recommended.
BI-RADS category 4: Suspicious for malignancy (>2% but<95% likelihood of cancer), tissue diagnosis is recommended.
BI-RADS category 5: Highly suggestive of malignancy (≥95% likelihood of cancer), tissue diagnosis is recommended.

In this study, BI-RADS categories 1-3 were considered negative, while categories 4-5 were considered positive for malignancy. In addition to assigning BI-RADS to the examinations, breast parenchymal density was determined using protocols of the American college of radiology (ACR),[1] whereby (ACR: A) was categorized as almost entirely fatty (less than 25% fibroglandular tissue); (ACR: B) was categorized as scattered areas of fibroglandular densities (approximately 25% to 50% fibroglandular); (ACR C) was categorized as heterogeneously dense (approximately 51% to 75% fibroglandular); and ACR 4 was categorized as extremely dense (more than 75% fibroglandular).

Standard Definitions

Data collection: The study received approval from the Mulago Hospital Research and Ethics Committee (Protocol No: MHREC 1545). Informed consent was obtained from all the participants prior to conducting the focus groups and interviews. The participants were also assured of the anonymity and confidentiality of their responses and no names were to be tagged to any response. Participants were also informed that they were free to withdraw from the study at any one time.

Mammography: Routine craniocaudal and oblique mediolateral views of both breasts were part of our examination protocol. Mammography exams were consistently performed using the in-clinic unit (Selenia, Hologic™ 2D Digital Mammography, USA). Images were reviewed using Belgian American Radio Corporation (BARCO) SecurView® DX digital 5 megapixels workstation).

Mammograms in our breast imaging unit were viewed by the radiologist for immediate workup. No further recalls were required for any presented images. The BI-RADS assessments given after imaging review were used for both sonographic and mammographic examinations.[1,2] No retrospective second interpretation was made. Final results of the Mammograms were categorized as true positive, true negative, false positive, or false negative according to standard definitions in the fifth edition of the BI-RADS atlas.[10]

Ultrasonography: Women deemed qualified for breast ultrasound examinations were examined on both breasts, including regional lymphatic areas. This was performed by the same radiologist interpreting final diagnostics results, and the real-time dynamic equipment (GE Voluson 730 pro, GE Healthcare, USA) was used for it has a high resolution phased-array transducer with a frequency that ranges from 7.0 to 12.0 MHz. Colour and Power Doppler were also available on the equipment.

Statistical Analysis

The collected data was analyzed using SPSS® for Windows®, version 15.0 (SPSS, Inc., USA). Quantitative (numerical) variables were represented for mean, range and standard deviation; qualitative (categorical) data was represented by number of cases and percentage. Analysis of categorical data was performed *via* a chi-square test. Multivariable analyses were done using logistic regression. *p*-value less than 0.05 was considered statistically significant.

RESULTS

A total of 4,791 participants were included in this study. The patient median age was 46.1. Approximately 31% (n=1,462) of the participants were less than 40-years-old. The participants had a mean (Standard Deviation) BMI of 28.2 (10.51). Thirty four % of the patients were overweight and 30.2% were obese. Majority of women (83.3%) had Muslim religion followed by 16.7% Christian. Patient characteristics are summarized according to their age categories in Table 1.

Older women had a higher obesity status compared to younger women (36.1% *vs* 16.6%, $p<0.0001$). Younger women had a higher Muslim religion compared to older women (89.5% *vs* 80.6%, $p<0.0001$). Older women had a higher malignant status (BIRAD results in 'malignant', or 'probably malignant') compared to younger women (6.8%; 3.8% *vs* 1.7%; 1.0%, $p<0.0001$)

The ACR density differed by age group. Older female presented more ACR[1] density than younger female (15.3% *vs* 8.6%, $p<0.001$). The family history of breast cancer was similar in both younger and older women (28.7% *vs* 29.3%). The breast feeding history was similar in both younger and older women (88.5% *vs* 88.4%). Additional patient characteristics are summarized according to their malignancy status in Table 2.

The older age group (older than 40-years) had a higher confirmed diagnosis of breast cancer status than the younger age group (10.0% *vs* 2.9%, $p<0.001$). Obese women had a higher confirmation status than the normal or overweight group (14.4%; 8.6%; 5.8%, $p<0.001$. Post-menopausal women had the highest malignant status, followed by pre-menopausal, and then peri-menopausal women (17.8%; 7.5%, 5.6%, $p<0.001$). Women with a family history for breast cancer had similar proportions of confirmation compared to the other cancer group (6.2% *vs* 4.8%). Muslim women had a higher malignant status than Christian women (8.6% *vs* 5.5%, $p=0.0268$). Women who breast fed had similar proportions of confirmation compared to the non-breast feeding

women (11.2% *vs* 9.4%, p=0.2027).

Table 2. *Confirmed Diagnosis and Patient Characteristics*

Characteristics n (%)	n	(%)	*p*-value
Age			
<40	38	3.51	< 0.0001
≥ 40	300	10.70	
BMI			
Normal	45	5.06	< 0.0001
Overweight	87	9.73	
Obese	109	12.73	
Religion			
Muslim	300	9.33	0.0021
Christian	38	5.65	
BIRAD			<0.0001
Negative/Normal/Benign/ Probably Benign	0	0	
Probably Malignant	81	59.56	
Malignant	250	90.58	
ACR			
ACR1	60	12.63	0.0227
ACR2	147	8.84	
ACR3	79	9.61	
ACR4	12	5.83	
Family History			
Breast CA	84	7.11	0.0543
Other CA	5	7.14	
NA	249	9.45	
Menopausal			
Pre	103	6.25	<0.0001
Peri	11	8.03	
Post	171	16.18	
Breast Feeding			
Yes	159	11.55	0.0019
No	48	18.53	

BMI: Body mass index; ACR: American college of radiology; CA: Cancer; NA: Not available

To test whether age was an independent risk factor of malignancy status, a multivariate analysis was performed using a logistic regression. In the multivariate analysis, being older (>=40-years), being obese, and being post-menopausal were significant predictors for confirmed diagnosis. A woman's religion was marginally significant (p=0.0899), Table 3.

The unadjusted odds ratio (OR) of confirmed status associated with older age women was 3.3. After the adjustment for clinical and other demographic factors, OR (95% confidence interval) of older women having confirmed diagnosis was 2.32 (1.19, 4.50) times more likely than younger women. BMI, menopausal status, breast feeding history did contribute to the improvement of the model. The obese group was 1.83 (1.10, 3.03) times more likely to present the confirmed status than the normal group. The post-menopausal group was 1.64 (1.07, 2.50) times more likely to present the confirmed status.

Table 3. *Multivariate Logistic Regression Analysis: Predictors of Malignant Diagnosis*

Variables	OR	95% CI	*p*-value
Age			
<40	1		0.0481
≥ 40	1.75	(1.01, 3.05)	
BMI			
Normal	1		0.0017
Overweight	1.72	(1.09, 2.70)	
Obese	2.23	(1.44, 3.45)	
Religion			0.0086
Muslim	1		
Christian	0.48	(0.28, 0.83)	
Menopausal			0.0023
Pre	1		
Peri	1.74	(0.83, 3.67)	
Post	1.93	(1.33, 2.81)	
Breast Feeding			0.0002
Yes	1		
No	2.12	(1.43, 3.14)	

BMI: Body mass index

DISCUSSION

We found that older females were more likely to have less dense breasts (ACR A) compared to younger females, while women older than 40 had a higher confirmed number of breast cancer diagnoses compared with the younger age group. In addition, our results suggested that women with breast cancer were more obese and not having breast feeding history. Studies have suggested that Arab women present with breast cancer at younger ages.[11] In contrast to these reports, in our study older women had higher confirmed cases of BC. Our study is limited by the quality of information reported from a large imaging center and a retrospective review although the study is based on the best available data. Statistical analysis is based on association not causation.

Our study is limited by the quality of information reported from a large imaging center and a retrospective review although the study is based on the best available data. Statistical analysis is based on association not causation.

Age-standardized cancer incidence varied substantially between EMR countries with infection-related cancers playing a more important role in low and low-middle income countries (e.g., stomach

cancer having the highest ASIR in Afghanistan, Iran, Yemen, and Sudan, and cancers related to low physical activity and cancers with strong lifestyle-related risk factors such as colorectal cancer being more common in middle- and high-income EMR countries such as Lebanon, the UAE, and Libya). Breast cancer is markedly affected by association between age, breast density, and other demographic factors of breast cancer patients, and with different radiological breast diagnoses categories.

Environmental factors might contribute to breast cancer incidence rate and prevalence. Studies show high BMI is linked with increased risk for breast cancer for women in post-menopausal stage.[5]

Taken together, our study conducted in this large cohort demonstrated that trends of BC in Egypt, including risk factors resemble that of women of European descent. This is akin to a study published by Salhia et al demonstrating that Egyptians appear to have a molecular subtype distribution like that of Western women, where Luminal A BC represents the largest fraction of cases.[13] Still women of Egyptian and Arab descent have advanced disease at diagnosis and high mortality. Awareness, early detection, lifestyle and access to care are the key to combating BC in Egypt. Intervention at the public health level, including education on the benefits of early detection is necessary and would likely have tremendous impact on breast cancer outcome in Egypt. Obesity is a risk factor for BC, prevention strategies including engaging women in healthy eating and physical activity would also have an impact on BC epidemiology in the area.

CONCLUSION

BC epidemiology in the Arab region remains understudied compared with Western countries. Women in the Eastern Mediterranean Area (EMR) have higher cancer incidence rate but less cancer deaths in comparison to males, which might be attributed to less aggressive cancers (breast, cervical) being among the top cancers in females compared to lung and stomach cancer in males.[12]

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DISCLOSURES

Gewefel HS disclosed no relevant relationships. Michelen S disclosed no relevant relationships.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Case Report

A Familial Case of Spontaneous Regression of Colloid Cyst of the 3rd Ventricle on Magnetic Resonance Imaging

Deepsha Agrawal, MBBS*; Athanasios Grivas, MD; Ancy Joseph, MBBS

Institute of Neurological Sciences, Queen Elizabeth University Hospital, Glasgow, UK

Corresponding author
Deepsha Agrawal, MBBS
Foundation Doctor, The County Durham and Darlington NHS Foundation Trust, UK; E-mail: deepsha.agrawal@nhs.net

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ABSTRACT

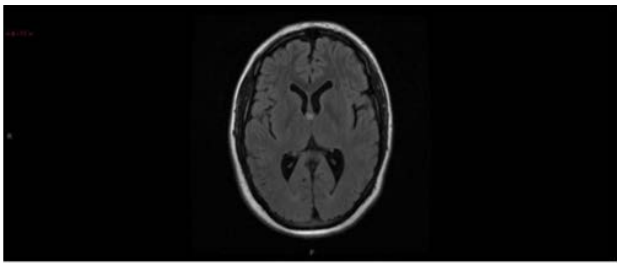
A 21-year-old male underwent screening for a positive family history of colloid cyst with an MRI scan. This suggested a lesion in the region of the roof of his 3rd ventricle which was confirmed on a computerized tomography (CT) scan as a colloid cyst measuring 6 mm. Seven-years before his evaluation, the patient's father was found to have an approximately 20 mm colloid cyst with acute hydrocephalus for which he underwent excision. His sister suffered a sudden death at the age of 25. The cause of death was confirmed on autopsy as a colloid cyst which was undiagnosed and associated with acute hydrocephalus. At the time of evaluation, the patient was asymptomatic. On serial imaging in 1-year, there was a definite increase in size of the colloid cyst which now measured 8 mm along its maximum dimension. The colloid cyst also changed in signal intensity appearing more hyperintense on T2-weighted images and fluid-attenuated inversion recovery (FLAIR) sequence. A serial magnetic resonance imaging (MRI) was performed in 18-months as a part of ongoing surveillance with neuroimaging following the first presentation. This demonstrated a decrease in size and change in the shape of the colloid cyst, measuring 5 mm in maximum dimension, with associated decrease in ventricular size and resolution of hydrocephalus suggesting some spontaneous rupture of the colloid cyst. A CT head with unenhanced volume acquisition of the head demonstrated residual partially international organization for standardization (ISO), partially hyperdense colloid cyst seen at the foramen of Monro. This confirmed the findings of MRI with a decrease in size of residual colloid cyst measuring approximately 5 mm in maximal diameter with no residual hydrocephalus.

Keywords
Neuroradiology; Central nervous system cysts; Colloid cyst; Magnetic resonance imaging; Third ventricle; Foramen of Monro.

INTRODUCTION

Colloid cysts of the third ventricle are histologically benign epithelial lined tumours, characteristically located in the foramen of Monro. The incidence of this lesion is 3.2 per million per year, making up to 0.5 to 2% of all intracranial tumours. Majority of cases present between second and fourth decades of life. Sixty percent of colloid cysts are found incidentally and are asymptomatic. Of the remaining minority of 40%, the most common presenting complaint is headache as a sequelae of hydrocephalus. The development of hydrocephalus can be attributed to their position in the roof of third ventricle in close proximity to the foramen of Monro. This results in obstructive hydrocephalus resulting in sudden thunderclap headache. Other reported symptoms are nausea/vomiting, blurred vision or diplopia, dizziness or ataxic gait, cognitive decline, syncope, and sudden death due to untreated hydrocephalus and raised intracranial pressure (ICP).[1] The natural history of colloid cyst of the third ventricle is widely variable and depends on patient demographic characteristics, presenting symptoms, and cyst diameter. Incidental lesions in asymptomatic patients are managed with serial imaging. 8.8% of these incidentally discovered lesions enlarge. The lesion appears as a well-delineated hyper attenuated mass on non-enhanced computerized tomography (CT). On magnetic resonance imaging (MRI) it appears isointense to hyperintense on T1-weighted images and hypo intense to hyper intense on T2 sequences (Figure 1). It is difficult to recognize colloid cysts with fluid-attenuated inversion recovery (FLAIR) sequence, which are hypointense on T2-weighted evaluations; however, they have been reported to appear similar to attenuated cerebrospinal fluid (CSF) on FLAIR.[2]

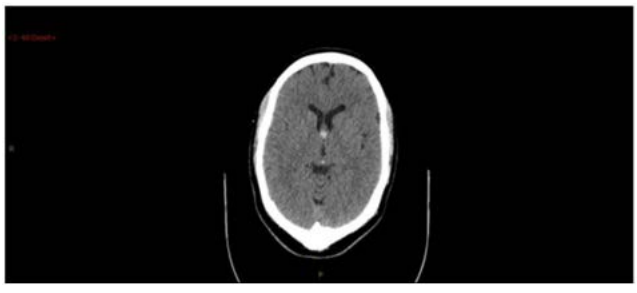
Figure 1. *A Colloid Cyst Measuring Approximately 8 mm along its Maximum Dimension. Appears Hyper Intense on T2-weighted Images and FLAIR Sequence*



CASE PRESENTATION

A 21-year-old male underwent screening for a positive family history of colloid cyst with an MRI scan. This suggested a lesion in the region of the roof of his 3rd ventricle which was confirmed on a CT scan as a colloid cyst measuring 6 mm with no associated hydrocephalus (Figure 2). Seven-years before his evaluation, the patient's father had presented with headache and confusion and was found to have an approximately 20 mm colloid cyst with acute hydrocephalus for which he underwent excision. His sister suffered a sudden death at the age of 25. The cause of death was confirmed on autopsy as a colloid cyst which was undiagnosed and associated with acute hydrocephalus. She had suffered from intermittent headaches associated with some confusion for many months, and over a 4-day period, she developed severe headache following which she attended accident & emergency department (A&E) and was sent home with a suspected urinary tract infection (UTI). She died at home whilst lying on the couch 4-days later. At the time of evaluation, the patient remained well with no history of headaches, dizziness, any cognitive deterioration, vomiting, balance impairment or seizures.

Figure 2. *CT Demonstrating a Colloid Cyst Measuring 6 mm with a Hyper Dense Focus in the Superior Portion of the Third Ventricle. There is No Evidence of Obstructive Hydrocephalus.*



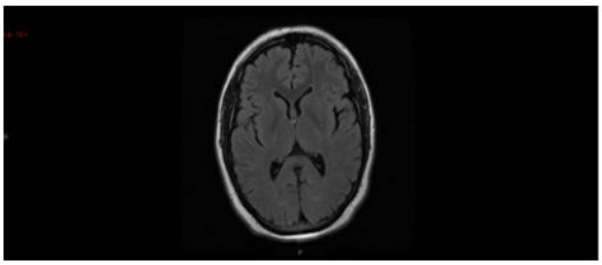
On serial imaging in 1-year, there was a definite increase in size of the colloid cyst which now measured approximately 8 mm along its maximum dimension. The colloid cyst also changed in signal intensity on comparison with previous scan appearing more hyperintense on T2-weighted images and FLAIR sequence. There was a slight increase in size of the lateral ventricles on comparison with previous scan. A neuropsychology assessment concluded that no notable cognitive dysfunction. An early surgical intervention was suggested on the rationale of changes in the density of the cyst, the morphology, the size of the ventricles and the strong family history. The patient remained clinically well through this period. A serial MRI was done in 18-months as a part of ongoing surveillance with neuroimaging.

This demonstrated a decrease in size and change in the shape of the colloid cyst, measuring 5 mm, with associated decrease in ventricular size and resolution of hydrocephalus suggesting some spontaneous regression of the colloid cyst. A CT head with unenhanced volume acquisition of the head demonstrated residual partially international organization for standardization (ISO), partially hyper dense colloid cyst seen at the foramen of Monro. This confirmed the findings of MRI with a decrease in the size of residual colloid cyst measuring 5 mm with no residual hydrocephalus.

OUTCOME

In the context of rare phenomenon of reduction in size, the risks of surgery for the small remnants of the cyst were disproportionately high in relation to the risk from the cyst. Surgery was deferred and a follow-up MRI imaging was done in 8-months which demonstrated a small colloid cyst at the size of 4 mm (Figure 3). Further CT imaging was not done given the age of the patient and potential risks of radiation. The patient remained well.

Figure 3. *A Solitary Focus of T2/FLAIR Hyper Intensity in the Sub-cortical White Matter of the Left Frontal Lobe Appears Smaller than Previous. There is a Normal Appearance of the Ventricular System.*



CONCLUSION

Familial cases of these lesions is extremely rare.[3,4] There is a lack of evidence on the role of genetic factors in the development of these lesions. Insights into the function of "paired"-like homeodomain transcription factor (Prop1) in the development of Rathke's pouch, the pituitary primordium, have been described in mice. The projections of these concepts into human genetics and pathophysiology have not been studied thoroughly.[5] The mechanism for reduction in size remains uncertain, however, there have been reports of spontaneous regression mostly in children and asymptomatic adults.[6-9]

LEARNING OUTCOME

It is important to remember that colloid cyst although rare is an important differential diagnosis of hyper attenuated mass on non-

enhanced CT, particularly in the region of foramen of Monro. However, there are reports of colloid cysts at unusual locations such as lateral ventricle and posterior fossa. The main challenge in diagnosis remains late presentation and sudden death due to hydrocepahlus. Differential diagnoses include other masses arising in the region of foramen of Monro like meningioma, glioma, metastasis and blood in the region. There should be a low threshold for imaging in patients with a family history of colloid cyst of the third ventricle.

CONSENT

The authors have received written informed consent from the patient.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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An Exploration of the Perceptions of Radiology Professionals towards Point of Care Ultrasound Training for Non-Radiology Health Care Providers

Aloysius G. Mubuuke, PhD*; Francis Businge, MSc

Department of Radiology, School of Medicine, Makerere University, P. O. Box 7072, Kampala, Uganda

Corresponding author
Aloysius G. Mubuuke, PhD
Department of Radiology, School of Medicine, Makerere University, P. O. Box 7072, Kampala, Uganda; Tel. +256772616788; E-mail: gmubuuke@gmail.com

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ABSTRACT

Introduction
Point of care ultrasound (POCUS) has been adopted across many countries as a way of addressing the human resource gap of radiologists and sonographers. It involves providing basic and focused ultrasound skills to non-radiology health care providers to enhance their routine clinical work.

Objective
The purpose of this study was to explore the perceptions of radiology professionals about POCUS training.

Methods
The study was qualitative, involving radiologists and sonographers who perform ultrasound examinations. Purposive sampling was used to select the participants. Purposive sampling is a type of sampling where participants are selected because they have the knowledge and experience needed to answer the research objective. Focus group discussions and individual interviews were used to collect data and thematic analysis employed.

Results
Participants generally held negative perceptions towards POCUS training. These were reflected in four major themes: 1) Absence of standardized training curriculum; 2) Limited consultations with radiology professionals; 3) Fear of loss of professional identity and 4) Challenges with POCUS training.

Conclusion
The participants felt negatively about POCUS training. For future acceptability, we recommend involvement of radiology professionals in designing a POCUS curriculum as well as having a regulatory mechanism for monitoring the trainees.

Keywords
Point of care ultrasound (POCUS); Training; Perceptions; Radiology professionals.

INTRODUCTION

Point of care ultrasound (POCUS) has been adopted across the globe to address the human resource gap in areas where radiology professionals (radiologists and sonographers) cannot easily be accessed.[1,2] POCUS is aimed at equipping non-radiology professionals such as nurses, mid-wives, clinical officers and doctors with basic ultrasound skills to enable them perform their routine clinical tasks. It is thus used as a tool to aid routine standard of clinical care. The non-radiology professionals that have undergone point of care ultrasound training are ideally not expected to write comprehensive radiological reports, but rather the ultrasound skills gained just assist them to make instant clinical decisions at their point of work. The comprehensive ultrasound investigations remain the domain of qualified radiologists and sonographers.

The less developed countries still have challenges in delivering adequate care to their populations. It has been reported that many people in such countries still lack access to basic ultrasound services.[1,2] However, ultrasound plays an important role as

a diagnostic tool across all countries. This is because it is relatively affordable, portable and uses non-ionizing radiation. Previous studies have reported the utility of ultrasound in medical, surgical, and obstetric care settings.[3,4] As part of the routine antenatal care, many women are now required to at least undergo an obstetric ultrasound scan during their pregnancy as it has the potential to identify high-risk pregnancies and pregnancy-related complications. However, many countries still face the challenge of having few radiologists and sonographers who are specially trained to perform ultrasound scans. In many rural areas for example, there are no radiologists/sonographers at all, leaving these areas devoid of qualified professionals to perform the ultrasound scan examinations.

One way that has been suggested is to have role extension, where non-radiology health professionals are equipped with basic skills to perform emergency ultrasound scans during routine clinical care. As a result of the importance of the significant clinical role of ultrasound in diagnosis, POCUS training programs have been initiated especially in less developed countries in order to equip non-radiology health workers with basic skills to perform emergency ultrasound scans.[1] POCUS training programs have been introduced in many areas across the globe with some level of success.[5-7] For example, Kenya commenced POCUS training in 2013 having realized that radiologists and sonographers were scarce in many rural based health facilities.[8] Health care in such rural health facilities was being provided by clinical officers (mid-level providers with a diploma in clinical medicine), nurses/mid-wives, and community workers. These health workers were equipped with skills to perform basic ultrasound applications.[8] Similar POCUS training programmes have been reported elsewhere.[9-15]

In Uganda, where this study was conducted, maternal mortality due to pregnancy-related complications remains high especially in rural communities. Some of these pregnancy-related complications can be detected early during obstetric ultrasound and timely management effected. The government has equipped many lower level health facilities with basic ultrasound equipment. However, despite these efforts, the lack of skilled workers to utilize this equipment and provide the much-needed basic service is frustrating government's efforts, thus still having women die due to undetected, but avoidable pregnancy-related complications. There are few professionally trained health workers (radiologists and sonographers) that can ably perform obstetric ultrasound and the few who are trained only remain in the more lucrative private hospitals and large public hospitals in the urban centres. Thus, women in rural communities continue to die from pregnancy-related complications that are often not detected early enough using ultrasound. In order to address the human resource gap POCUS training for non-imaging professionals has been suggested. However, there is still concern especially among the radiology fraternity about this POCUS training. At the same time, there is a dearth of published literature about the perceptions of radiology professionals towards such point of care ultrasound training programs. Therefore, the purpose of this study was to explore the perceptions of radiology professionals towards point of care ultrasound training to non-radiology health professionals. It is hoped that findings from the study can further inform the design and implementation of such programs not only in Uganda, but also in other countries.

METHODS

Design

It was an exploratory qualitative study conducted within the Department of Radiology of Mulago National Referral Hospital in Uganda.

Participants

The study included radiologists and sonographers. Purposive sampling was used to select the participants. Purposive sampling is a type of sampling where participants are selected because they possess knowledge and experience about the study subject that is required to address the study objective. Fifteen (15) sonographers and 5 radiologists were selected to participate in this study. The final number of participants was determined at the point of data saturation.

Data Collection and Analysis

Focus group discussions (FGDs) and structured individual interviews were used to collect data. Three FGDs were conducted with the sonographers, each group having 5 participants and 5 interviews were conducted with the radiologists. It was not possible to conduct FGDs with the radiologists due to their busy schedule. Responses from the FGDs and interviews were audio-recorded and thereafter transcribed verbatim. Thematic analysis was employed. This was done through a process of open coding. Coding commenced immediately after the first focus group discussion and immediately after the first interview.

Ethical Issues

Approval to conduct this study was granted by the Mulago Hospital Ethics Committee and participants provided written informed consent prior to enrolling into the study. Confidentiality of the participant responses and transcripts was ensured. The transcripts were kept by the researcher and locked in a safe. Electronic information was secured with a password only known to the researcher.

RESULTS

The study recruited 20 participants of whom 15 were Sonographers and 5 were radiologists. Of the 20 participants, 7 were female and the rest were male. All participants were actively involved in providing ultrasound clinical services in the radiology department of Mulago Hospital. Table 1 summarizes the major themes that emerged.

Theme 1: Absence of a Standardized Training Curriculum

All participants in this study expressed concern with the haphazard manner in which the POCUS training has been happening in Uganda. They reported that there is no specific curriculum that is followed and that all people involved in this training have been

Table 1. *Themes and Related Key Issues that Emerged*

Theme	Key Issues
Absence of standardized training curriculum	• Lack of guiding training curriculum • No stipulated duration of training • No clear expected competencies/Outcomes • Lack of assessment/evaluation methods
Limited consultations with radiology professionals	• Radiologists not consulted • Sonographers not consulted • No involvement of radiology associations • Unclear roles of radiology professionals
Fear of loss of professional identity	• Loss of professional territory • Dilution of the professions • Unlimited opening up to other staff
Challenges with POCUS training	• No regulatory framework for trainees • No supervisory framework • Fear of going beyond real competency • Misuse of ultrasound services • Risks to patients • Possible law suits

suggesting to use training curricular got from outside the country yet the context of Uganda is quite unique. The following responses represented this feeling.

"*There is no curriculum that is followed in this kind of training…...how far can one go with the training and what competencies are going to be taught. There is need to clearly define competencies that a nurse for example will be required to demonstrate before rolling out such training.*"

"*One mistake that is being done is to train with imported training documents. We have unique challenges and one cannot just adopt training materials from abroad…...what level of ultrasound will a nurse do, a doctor do, a mid-wife do or a clinical officer do? These people require different skills and you cannot just bundle them altogether.*"

The importance of having a training curriculum was also reflected in the duration of training as can be seen from the following response:

"*I have heard some people proposing 2-week training. Surely what can one learn in 2-weeks and call themselves competent.*"

The above responses point to the need of first defining competencies for each cadre of targeted staff and having a guiding document in form of a curriculum that can be followed.

Theme 2: Limited Consultations with Radiology Professionals

The responses from both FGDs and interviews generally reflected ignorance of starting point of care ultrasound training to non-radiology health workers in Uganda. All participants reported that they never received any invitations consulting them about the POCUS training. This ignorance can be seen through the following responses:

"*We would expect that if POCUS is good and with no ill-intentions, stakeholders need to be consulted. As radiology professionals who struggled to take on lengthy training in ultrasound, we are not being consulted regarding this at least to the best of my knowledge.*"

"*…. before starting this kind of training, we all need to be consulted through our regulatory bodies and associations. This has not been and I highly doubt this can work without such consultations taking place……a few individuals should stop thinking that they will gain from this and bring everyone on board if we are to support it.*"

From these responses, it can be seen clearly that the trained people who perform ultrasound services need to be consulted before taking on such role-extension to other groups of health workers.

Theme 3: Fear of Loss of Professional Identify

The fear to lose professional identity and uniqueness was a common thread through the discussions and interviews. The common denominator in almost all participant responses was that radiology is being sold to other health cadres and that the discipline is slowly being infiltrated thus the traditional radiology trained health care workers (i.e. radiologists and sonographers) are likely to slowly lose their identity and territory. The following responses can reflect this:

"*If we let other people invade the radiology professions and especially ultrasound, we shall lose relevance since employers will be at liberty to employ a nurse for example who can also do ultrasound.*"

"*Every profession must protect its boundaries……I doubt if it is possible at all for the surgeons for example to allow me train for 2-weeks and start doing hernia repairs…they will all be up arms. Unfortunately, this POCUS business is meant to water down ultrasound services such that anybody can do it…...this means we are soon becoming jobless.*"

One can infer from the above responses that there is inherent fear for radiologists and sonographers when other people try to invade their professional territory. POCUS training is thus viewed as a means meant to open up the professions to many other non-radiology health care workers.

Theme 4: Challenges with POCUS Training

This was also a major theme with participants pointing out signifi-

cant challenges with the proposed POCUS training. Key among these were; a lack of a regulatory and supervisory framework for other cadres trained in point of care ultrasound, lack of well-defined competencies expected of the POCUS trainees, limited control of the extent to which the POCUS trainees can practice thus exceeding their competency and bringing danger to patients. These challenges can be sieved through the following responses:

"*The question of which regulatory body will be regulating and supervising nurses and doctors while they are doing ultrasound is not yet resolved. This thus leaves these people to practice ultrasound without regulating them and this is dangerous.*"

"*The problem is that no one will control these people. Even if you train them with some basics, they will go out there and practice ultrasound scanning each and every body part presented simply because it is profitable…. this is dangerous to both the profession and human life. I foresee people diagnosing non-existent pathologies and subjecting patients to real danger including death.*"

"*The issue if commercialization of health care. Ultrasound is now everywhere and if you release quarter baked people into society to practice ultrasound, it is our profession that suffers. The truth is that these people will practice beyond what they can handle simply because the patient pay.*"

There were some suggestions that resonated through the responses that could guide in implementing such POCUS training.

"*I think POCUS training is every well intentioned. However, lets first sort out issues of defining clearly what these people are expected to do and how they are going to be regulated.*"

"*We all need to be consulted because we are stakeholders in this profession, so we cannot let it crumble. It is not that we are against POCUS training, in fact it is good. However, we should go through the right channels of doing it instead of rushing it. First do a small pilot study to assess its feasibility and then sort out the training curriculum with all of us involved because at the end of the day, these trainees will be referring to us already messed up patients. Let's also be sure how they will be regulated not to practice beyond what they have been trained to do.*"

DISCUSSION

The purpose of this study was to explore perceptions of radiology professionals (radiologists and sonographers) towards point of care ultrasound training for non-radiology health care providers. Findings from the responses generally reflect negative perceptions towards POCUS training that targets non-radiology professionals such as nurses, physicians, mid-wives and clinical officers. This kind of negativity has been previously reported.[14,15] From this study, there seems to be fear among the radiologists and sonographers that their territory is being invaded by cadres in the health care system and as such may lose their own professional identity and their roles in the healthcare team. POCUS training for non-radiology professionals has been previously reported with some level of success.[4-8] Many of these studies have also reported good receptivity of this kind of training among the radiology professionals. In this study, POCUS training was generally received with negativity. Closely interrogating reasons as to why POCUS training received such negativity among participants in this study points to a number of them.

First, the lack of clearly well-defined ultrasound competencies for the different cadres of health workers was a concern. For example, the ultrasound skills needed by a nurse or mid-wife may quiet differ from those skills needed by a clinical officer or medical officer and thus cannot be trained together due to this. It would be plausible to first clearly define ultrasound competencies needed by each cadre of health worker in order to perform their routine clinical work. Defining these competencies thus drives the designing of the curriculum including the duration needed to impart such skills.

The idea of simply adopting POCUS training curricular from elsewhere needs to be revisited. Different countries have different contexts as well as resources for training. For example, a 2-week POCUS training course may be adequate in Europe due to availability of equipment and protected time. However, it might not be adequate in the context of a less developed country with inferior and limited equipment as well as limited human resource capacity. Therefore, the curricular need to be adapted and contextualized to each individual country. This observation has been emphasized in previous literature.[8] In relation to this, there is need to involve local stakeholders from the design to implementation of the POCUS curriculum. The radiologists and sonographers are important stakeholders in this process because they will be called upon to supervise the trained nurses or mid-wives. Stakeholder involvement is more likely to lead to acceptance and collaboration.

An important finding from this study related to supervision and regulation of the trained nurses, mid-wives or clinical officers. It is expected that the people that have undergone POCUS training will not write reports, but rather utilize the skills gained to enhance their normal clinical work. However, it is also a challenge to ensure that these trained people actually stick to their boundary and prevent possible litigation due to practising beyond their competency, an observation that has been reported elsewhere.[14] Herein lies the fear of the radiology professionals. In the current POCUS training environment, there is no regulatory and supervisory framework to follow-up the trainees and to ensure that they do what they are mandated to do. It is thus advisable that the current supervisory mechanisms come together to map out ways in which such trainees will be supervised. The fear that such people can be a danger to patients as expressed by participants in this study needs to be taken seriously. With the commercialization of ultrasound services, it is easy for anybody with basic skills to start scanning patients including conditions beyond their own competency. Therefore, before POCUS training can start, the issue of regulation needs to be looked into.

It is however interesting to note that the radiologists and sonographers who participated in this study seemed to be in support of POCUS training and role extension of some ultrasound skills to non-radiology health care providers to enhance their clini-

cal work. This is a good entry point to start with. The point of concern thus appears to be the undefined scope of practice, absence of a curriculum with well-defined competencies for each cadre of staff, absence of a regulatory and supervisory framework as well as limited involvement of the radiology professionals as key stakeholders. It is advisable that these people get involved in discussions and that all these aspects need to be looked into if POCUS training is to be acceptable in this setting. Specifically, a training curriculum contextualized to a particular setting and to a particular cadre of health worker needs to be developed with adequate time given to master the skills. This coupled with the fact that having a regulatory mechanism in place were strongly reflected in the participant responses, policy makers need to look into these. The fear of invading the radiology professional territory also needs to be addressed by for example benchmarking in other areas where POCUS has been successful. One would think that this only requires a mindset change. However, more research is needed to fully ascertain this. This being a purely qualitative study conducted in one setting limits the generalizability of the findings. However, the study still provides useful insights and stimulates debate on the issue of POCUS training and role-extension of ultrasound skills to other non-radiology professionals. Insights from other settings would thus be a welcome addition to this discourse.

CONCLUSION

This study has shown that despite the fact that point of care ultrasound training for non-radiology professionals may be well intentioned, the radiologists and sonographers still have a negative perception towards it. This is mainly because it is seen as an invasion into their profession and there is no regulatory and supervisory framework to monitor the trained health workers. Acceptability in future is likely to be achieved through involvement of radiologists and sonographers in the process and having a regulatory mechanism for the trainees in place.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Opinion

Breast Density and the Efficacy of Secondary Screening

Greg Martin, BS, MR, CT, and Ultrasound*

Radiology Imaging Consultant- Women's Health, Hitachi Healthcare Americas, Twinsburg, OH 44087, USA

Corresponding author
Greg Martin, BS, MR, CT, and Ultrasound
Radiology Imaging Consultant- Women's Health, Hitachi Healthcare Americas, Twinsburg, OH 44087, USA; E-mail: gregmedicalsales@gmail.com

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The topic of density in relation to breasts has become a major issue of discussion as of late. Dense breast tissue refers to the breast tissue appearing on a mammogram. When a patient is told their breasts are dense this means that additional screening options may be appropriate as cancerous masses can hide behind the tissue. Masses appear white in color on a screening, or hyperechoic. Breast tissue results in the same imagery, so imagine looking for a snowball within a blizzard. Malignant tumors can be masked in these situations; resulting in a mammogram with a negative finding, hence the recommendation for adjunct screening.

Roughly 40% of women have dense breasts.[1] Breast density is one of the strongest risk factors associated with breast cancer. It is a highly established predictor of cancer risk and a mammogram misses every other cancer in dense breasts.[2] The density can be categorized into 4 levels; A, B, C, D. The category of A would be a classification of a breast being almost entirely fatty, whereas the classification of D would be extremely dense. About 1 in 10 women fall into this latter category.

In general, women with breasts that are classified as heterogeneously dense or extremely dense are considered to have dense breasts.[3]

The question arises as to what this means if a patient is considered to have heterogeneously dense breasts. The awareness of density and its ability to mask abnormalities in a mammogram has prompted many states (over half) to require physicians to "notify" patients if they have dense breasts and to recommend getting adjunct screenings.

Universal density reporting will prevent later stage cancers and give ALL women access to an EARLY diagnosis – when most treatable and with better survival outcomes. computerized tomography (CT) data show a statistically significant increase in the detection of small, early and invasive cancers invisible by mammogram.[4]

Additional screening tests to mammography for women with dense breast tissue will increase detection by up to 100%. These invasive cancers, missed by mammography, are small, node negative and at an early-stage.[1]

Recommended Adjunct Screening Methods

Breast tomosynthesis or a 3-D mammogram: Tomosynthesis uses X-rays to collect images of the breast from multiple angles. A 3-D image of the breast is formed by computer software.

Breast MRI: An magnetic resonance imaging (MRI) acquires its images using magnets. MRI doesn't use radiation. Breast MRI is recommended for women with a very high-risk of breast cancer. This might include those with genetic mutations, etc.

Breast ultrasound: Ultrasound uses sound waves to aquire images and analyze tissue. A diagnostic ultrasound is commonly used to look into areas of concern a radiologist might have found on a mammogram.

Automatic breast ultrasound (ABUS): There are pros and cons to each. A 3-D mammogram is estimated to detect 1 additional cancer per 1,000. However, cancerous masses may be hidden behind dense breast tissue. The patient is also exposed to more radiation (although considered safe).[3]

A breast MRI detects 14 additional cancers in 1,000 but can have many false positives, resulting in unneeded biopsies and stress on the patient. The MRI is more cumbersome, involves the injection of a contrast dye, and it is quite an expensive exam which might not be covered by your insurance.

Breast ultrasound detects an additional 2-4 cancers per 1,000 but is less cumbersome nor does it require a contrast injection. However, handheld ultrasound exams are heavily dependent on the individual scanner and they do result in an increase in false positives as well.

This concern is reduced when the concept of ABUS is adopted. An ABUS unit takes the user dependence out of the exam as well as add an additional level of speed and efficiency. This advanced technology achieves a 3-D image that can "see through" dense breasts to reveal areas that the radiologist was not able to see behind the dense tissue.

During these procedures the patient is laid on their back (supine) or on their front (prone), depending on the particular brand. When the patient is supine, a mechanical arm is positioned over the body. The operator holds the arm as the transducer (object acquiring the image) is guided across the breasts from side to side (transverse) as well as up and down (longitudinal). Each breast typically takes 2-3-minutes, depending on the brand.

When the patient is laid prone, conversely, the breast is placed within a cup and the transducer moves along the breast clockwise, acquiring three dimensional (3D) images without the use of a mechanical arm or added pressure (the patient's body weight suffices). For this reason, the comfort level can be increased within a prone position as well as the amount of privacy the patient has.

Some of the concerns radiologists have with this modality is the amount of false positives. They do not want to add unneeded fear to the patient. A recent study found that the call back rates were actually smaller than previously assumed with novice users producing call back rates at 3%, intermediate at 15.2% and advanced users at 7.1%. There was a decrease of average call back rates after a 3-month learning curve, down from from 24.7% to 12.6%. [5]

Is Automatic Ultrasound as Efficient as Handheld Ultrasound?

The Multicenter Hospital-based Diagnostic Study conducted to test the efficacy of ABUS *versus* hand-held ultrasound. The agreement rate between the two was 94% out of 1,973 studied. 78.6% were classified as breast imaging reporting and data system (BI-RADS) 4-5 and diagnosed with precancerous lesions or cancer, which was 7.2% higher than HHUS at 71.4%. For Birads 1-2 the false positive was nearly identical between the two modalities and much less than mammography (ABUS: 17%, Mammo: 27.5%).[6]

With the adoption of the notification laws taking place across the country, patients have more access to information related to the topic of density in relation to breasts. It still widely remains the patient's responsibility to seek out these additional screenings and check around to see what facility offers the screening methods they feel most comfortable with.

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Systematic Review

Digital Tomosynthesis: Applications in General Radiography

Samantha Yew, BSc (Student)*; Euclid Seeram, PhD, FCAMART

Medical Radiation Imaging and Radiation Sciences, Monash University, Melbourne, Australia

Corresponding author
Samantha Yew, BSc (Student)
Medical Radiation Imaging and Radiation Sciences, Monash University, Melbourne, Australia; E-mail: samantha.yew21@gmail.com

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ABSTRACT

Aim
Digital tomosynthesis (DT) is a novel imaging modality that has yet to be adopted widespread in Australia, but has potential to enhance patient outcomes both in diagnosis and reducing radiation dose. A review of the literature was performed to develop an introduction to digital tomosynthesis, and identify its uses and viability in general radiography.

Methods
Scopus, Ovid, MEDLINE and PubMed were utilised initially to identify literature published within 5-years, using several search terms linked with AND and OR. Articles were assessed according to specific guidelines, and categorised. Journal databases, medical imaging vendor websites, and article references were also evaluated for relevant information.

Results
Based on tomography, digital tomosynthesis is offered as an add-on to general radiographic equipment from general electric (GE), Shimadzu™ and Fujifilm. It's technology involves a sweep of the X-ray tube over a limited angle onto a stationary flat panel detector. The data is reconstructed to produce multiple slices in the acquisition plane, providing limited depth resolution in a radiographic setting, at a substantially lower dose to computerized tomography (CT) examinations. It's use has been highlighted in orthopaedic imaging, in detecting occult fractures when radiography has ambiguous results. Additional uses are mainly in surveillance; digital tomosynthesis has higher sensitivity and similar specificity to radiography, and thus can be used to monitor solid lung nodules, nephrolithiasis and deterioration of arthritic conditions.

Conclusion
At a lower cost to CT, digital tomosynthesis has the potential to become a bridging modality from radiography to both save patient dose and reduce their overall waiting times. However, more large-scale studies are required to confirm this.

Keywords
Digital tomosynthesis (DT); Radiography; Medical imaging; Emerging imaging; Whole body imaging; Tomosynthesis; Future prospects.

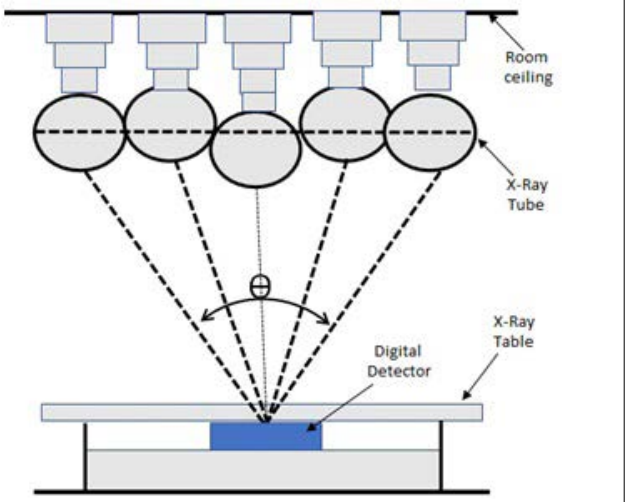
INTRODUCTION

Digital tomosynthesis (DT) is a unique imaging modality that has been recently developed for general radiography. In clinical practice, it has been researched and used primarily for mammography, where it involves a rotating detector and tube used to image the breast over an arc of up to 60°. The data is then reconstructed and displayed as an image stack that can be viewed as slices, which allows for additional volumetric and depth information to localise any abnormalities.[1] Although it has been widely adopted for clinical practice in breast imaging, there is less research on the use of DT in other parts of the body. There exists general radiography equipment that can perform DT however, there are only several units in use in Australia (Davidson R, 2018, unpublished data). Therefore, this literature review will focus on providing an introduction to whole body DT, from its basic parameters to how it is used in each region.

Digital tomosynthesis began as conventional tomography, where the X-ray tube and detector would move in opposite

directions over a limited angular range. Images would be acquired on film and only one central plane, called the fulcrum, would be in focus, blurring the anterior and posterior planes. More imaging was required to resolve other planes, resulting in excessive dose and increased examination time, which were barriers to its adoption in clinical practice.[2,3] Currently, DT employs a large flat panel detector technique. Rather than having both the detector and tube rotate, only the tube rotates over an angular range (θ) as illustrated in Figure 1.

Figure 1. *The Fundamental Principles of Digital Radiographic Tomosynthesis*



The data is then reconstructed, which allows for a specific plane to be resolved, and volumetric data is provided of a structure at a lower dose than a computed tomography (CT) scan.[3]

PURPOSE OF THE LITERATURE REVIEW

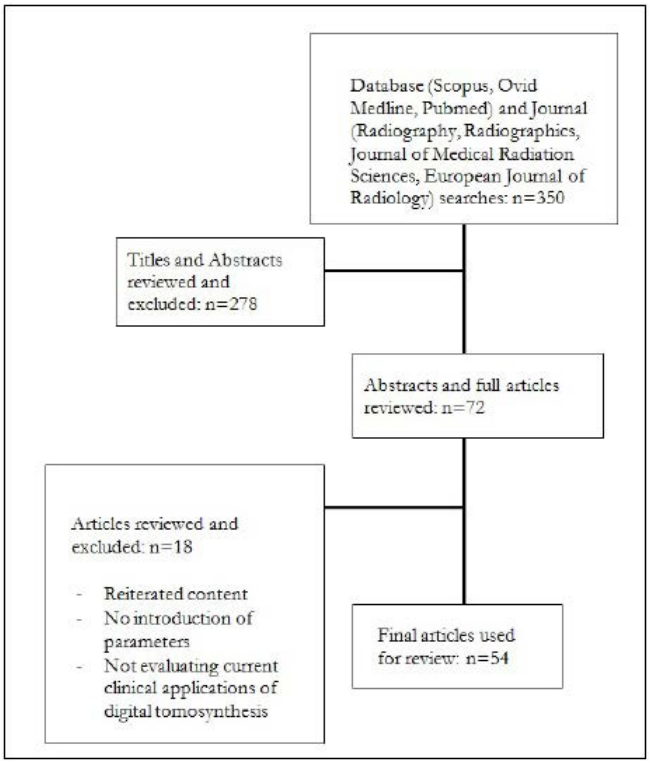
Research on DT has been conducted extensively in relation to breast imaging, but significantly less for other body regions. The purpose of this literature review is to investigate and identify the major uses of DT in those regions, and its use in clinical practice.

METHODOLOGY

An initial search was conducted through the databases Ovid, MEDLINE, Scopus and PubMed with keywords of DT in conjunction with multiple other terms. Specifically: "chest", "head and neck", "orthopaedic", "abdominal", "whole body", "acquisition parameters" and "reconstruction methods". The results were limited to articles in English that were published in the last five years, and can be seen in Figure 2. A subsequent reference search was conducted to identify additional relevant articles.

Vendors providing general radiography equipment capable of DT were identified through a search of their websites, specifically General Electric (GE), Shimadzu™, Siemens, Hologic™, Philips™, Carestream and Toshiba™.

Figure 2. *Flow Chart Diagram to Illustrate the Method Used to Determine Relevant Literature*



DISCUSSION

Principles and Parameters

Conventional digital radiography employs a static detector and tube, and produces a single projection. In comparison, DT acquires multiple low dose projections as the X-ray tube performs an arc over the region of interest, and therefore involves different parameters. In clinical practice, DT has been extensively researched and developed for breast imaging, where the gold standard is mammography. However, in denser breasts, detectability can be compromised as the breast tissue can mask any lesions.[1,4] Digital tomosynthesis provides a method to overcome this issue, allowing for depth localization without the increased dose from CT.

The same concept is used for DT of the whole body, where applications have been identified primarily in the chest, abdomen, head and neck, and extremities.[5] Besides the degree of breast compression, the parameters used for both breast and whole body tomosynthesis remain the same. In Figure 1, the movement of the tube can be seen in both vertical and horizontal applications, the angle or extent of motion is called the sweep angle, and the direction of movement: sweep direction. This would typically be from 20° to 50°, where 50° is ±25° from the centre. The number of projections acquired per movement of tube, calculated by dividing the total number of projections by the sweep angle, is called the projection density. Other important aspects to consider are the distance between the patient's skin edge to the object of

interest, barrier-object distance, and radiation dose. The total dose is calculated by multiplying the dose per projection with the total number of projections.[3,6]

To produce the viewable image dataset, there are different reconstruction methods that have been developed. Originally, back projection was used to reconstruct the data, where it followed a straightforward implementation method similar to the back projection used with CT. However, this lead to significant blurring and image degradation that further methods were explored.[2] Digital tomosynthesis involves a limited arc of the X-ray tube, compared to the revolutions that occur in CT. Therefore the same principles cannot be directly applied in reconstruction; CT relies on having enough sampled data in frequency space, but DT has incomplete sampling where entire regions are missed. This lead to filters being developed to address the blurring and discrepancies in DT specifically, which functioned to force the system to assume a uniform depth response over the range of frequencies obtained.[2] Essentially, they are low-pass filters applied in the frequency domain to suppress the high frequency information, and compensate for the sampling issues in tomosynthesis. The other two main methods of reconstruction are matrix inversion reconstruction, and iterative reconstruction. Matrix inversion reconstruction involves applying an algorithm inverse to the blurring that occurs in the data. Iterative reconstruction involves a loop where the projection data is processed through an algorithm, and goes through iterations until it reaches a set criterion. This may be a certain level of noise; therefore, a dataset with higher spatial resolution or sharpness may be obtained through iterative reconstruction. However, it is more computationally demanding compared to the other reconstruction methods, and therefore it is more common to see filtered back projection used for standard DT examinations.[7]

When interpreting the image set to determine their diagnostic quality, the key metrics are the in-slice resolution and the depth resolution. In-slice resolution refers to the smallest structure that can be resolved in a slice. Digital tomosynthesis uses filtered back projection to reconstruct the data into slices, which is applied in columns perpendicular to the focal path and results in lowered resolution vertically compared to horizontally.[3] The type of detector used limits the resolution in the horizontal plane, like in conventional digital radiography. Additionally, noise is dependent on the radiation dose, and can be reduced either by increasing the projections taken, or the dose for each projection.[3] For depth resolution, DT involves a limited sweep of the tube and detector, which doesn't result in full volumetric information, but can provide insight into the depth of structures. With a larger sweep angle, there is greater differentiation per projection, resulting in improved depth resolution.[6] The other factors affecting image quality include artefacts, where the main occurrences are blurring, ghosting and ripple artefacts.[3,6,8]

Currently, there are three vendors that provide DT as an advanced optional application. GE, Shimadzu™ and Fujifilm offer DT with their general radiography systems; the Optima 656 Plus™, RADspeed Pro Edge and the FDR Visionary Suite™ respectively. In each system, DT can be used with both the wall-stand and table bucky, allowing for both supine and weight bearing or erect positions.[9-11] In their DT package, Shimadzu™ offers a metal artefact reduction reconstruction method called T-smart, which creates composites by separately reconstructing the regions with metal and without metal with iterative reconstruction. They also offer DT with the Sonialvision G4, which is a fluoroscopy system with a flat panel detector and removable grid. The tube is connected to the table, and can be angled to produce erect images for procedures such as barium swallows.[12]

Whole Body Applications

Chest tomosynthesis: Chest tomosynthesis performs imaging over a limited arc, blurring overlying anatomy to improve visibility of the lungs in the coronal plane, highlighting its potential to follow-up known nodules.[7] It also has applications in cystic fibrosis,[13] tuberculosis,[14] and asbestos-related diseases.[15]

Dose-wise, any examination involving DT requires a scout to plan out the procedure. For the chest, this would involve an initial chest radiograph (0.01 mSv) plus the actual DT (0.12 mSv), resulting in a total dose of 0.13 mSv for the examination.[16] This figure varies among the literature; many calculate the effective dose to be from 0.10 to 0.14 mSv,[17-20] with two stating higher values of 0.19 mSv, which may be from using different parameters or having a different patient samples.[16,21,22] An example of standard chest tomosynthesis parameters can be seen in Table 1.

Table 1. *Standard DT Imaging Parameters for Chest Tomosynthesis*[23-25]

Tube Voltage	Tube Current (mA)	Sweep Angle	Projections	Time (s)
100-120	0.04	30-40	50-60 74 (Shimadzu)	10-12 4.85 (Shimadzu)

In the detection of lesions and nodules, chest radiographs and CT examinations are typically used, where CT is considered the gold standard for characterizing lesions. However, there is a significant difference in dose between the two modalities. A CT Chest results in a dose of 4-8 mSv, or 1.5 mSv if a low dose examination is selected.[7] Standard chest radiography consisting of two projections results in a dose of 0.05 mSv, a postero-anterior projection being 0.01 mSv and a lateral, 0.04 mSv. Low dose CT is the gold standard imaging modality for monitoring lung lesions, but with a radiation dose difference of 0.05 mSv *versus* 1.5 mSv, alternative imaging modalities such as chest tomosynthesis have been considered.[16]

The sensitivity and applicability of chest tomosynthesis has been investigated in numerous articles, and whether it is a viable screening tool for at-risk patients. A multi-institutional study from Dobbins et al[26] compared chest radiography to chest tomosynthesis and dual energy radiography in the management of pulmonary nodules. This study used five radiologists from different specialties, and found that DT showed significant improvement in the detection of nodules compared to CR, with improved visibility in the lung apices. These results align with those of similar

studies,[27,28] suggesting its viability for nodule screening. However, DT can result in misinterpretation of extraparenchymal lesions, or solid pulmonary nodules below 6 mm, and should still be referred for a baseline CT if nodules have been detected.[19,23,24,29]

Despite these applications, chest tomosynthesis has significant limitations that should be considered when setting the correct exposure parameters. As there are multiple high-density structures outside the focal plane such as the ribs, it can be particularly prone to ripple or blurring artefacts. Additionally, chest tomosynthesis uses an acquisition time of around 10-12-seconds on a single breath hold, making it susceptible to motion artefacts which could lead to diagnostic errors in nodule detection. To combat this, using a higher projection density has been recommended, raising the number of projections to 60 with a 30° sweep angle.[5]

Abdominal tomosynthesis: Compared to chest tomosynthesis, there is significantly less literature concerning abdominal tomosynthesis. In the majority of these articles, the focus is of nephrolithiasis, where the current gold standard is non-contrast CT; it can demonstrate secondary signs of obstruction such as perinephric fat stranding and hydronephrosis. However, radiation dose is a significant concern. It has been shown that patients who have an acute stone episode will have a median of 4 diagnostic imaging studies the year following the occurrence, including 1.7 non-contrast CT examinations.[30] For younger patients who have recurrent stones, this would significantly increase their yearly radiation dose and their cancer rate, based on studies from atomic bomb radiation outcomes.[30] The dose from a standard non-contrast CT examination has been found to be as high as 9 mSv and 12 mSv for men and women respectively,[31] but low-dose non-contrast CT procedures for nephrolithiasis have been introduced, which must be below 3 mSv.[30-33] Although this is a significant reduction, research has been made into alternative imaging to further uphold the as low as reasonably achievable (ALARA) principle.

Conventional radiography, specifically the kidney-ureter-bladder (KUB) projection, and ultrasound are typically used for a patient presenting for potential renal stones, and follow-up imaging post-diagnosis. The detection rates of KUBs have been reported as 45-58%.[32] This low value has been attributed to overlying bowel, where a study by Liu et al[33] measured the detection rate to be 48.7% (n=66/138) and 66.7% (n=92/138) before and after bowel preparation. Digital tomosynthesis is a promising modality in regards to nephrolithiasis as the data is acquired in one sweep of the X-ray tube, and can be reconstructed to produce different focal zones in the coronal plane. This provides limited depth resolution and can allow for radiologists to scan the kidneys to accurately determine the location of stones. The blurring from DT also removes overlying bowel and aids detection.[32] In the same study by Liu et al,[33] they found DT to have detection rates of 94.2% (n=130/138) and 96.4% (n=133/138) prior to and post-bowel preparation.

Astroza et al[33] investigated the dose delivered by standard KUBs, DT and low-dose CT on a 173 cm tall anthropomorphic phantom weighing 73 kg. The dose for DT was found to be 0.83 mSv, compared to 0.63 mSv for the KUB and 3.04 mSv for the low dose CT. Although these values are from a standard patient size, and do not account for patient variation, abdominal tomosynthesis would be a viable screening modality for non-acute stone detection.[32,34] An example of standard parameters can be seen in Table 2, where the patient is imaged supine and over a breath hold.

Table 2. *Standard DT Imaging Parameters for Abdominal Tomosynthesis*[32,35]

Tube Voltage	Tube Current (mA)	Sweep Angle	Projections	Time (s)
85	630	30-40	17 slices reconstructed	5.5

Head and neck tomosynthesis: For the head and neck region, DT has been researched regarding the paranasal sinuses. As with the abdomen, there was significantly less literature available on the topic, with only 3 being within the search range of 2013 to 2018. All 3 pertained to the viability of tomosynthesis as a screening and follow-up tool for sinusitis where the current the gold standard imaging approach is CT or low-dose CT. For this region, the significant concern is the radiation dose to the radiosensitive regions such as the eye lens and the thyroid, especially as CT involves concentric arcs of the detector and tube. This results in a significantly higher dose to the region compared to standard radiography, which encompasses a two image radiographic skull series of a Caldwell and Water's view. For the eye lens, radiation-induced opacities occur with worsening severity from 0.5-2 Gy; CT, radiography and DT all have doses significantly below that threshold.[36,37] However, in populations such as paediatrics, who are ten times more sensitive to ionizing radiation, damage can occur to the eye lens with a cumulative exposure of 250 mGy.[36]

Yoo et al[37] compared sinus radiography and DT in radiation dose, sensitivity and specificity, using CT as a reference standard. The images were interpreted by radiologists with varying familiarity with DT, with no mention of blinding. For sinusitis, the two radiologists, (A and B) were found to have significantly higher sensitivities for DT (A: 96%, n=24/25; B: 92%, n=23/25) compared to radiography (A: 52%, n=13/25; B: 80%, n=20/25) with similar specificities.[37] This was corroborated by Machida et al,[38] who additionally found high sensitivities and specificities in the frontal, ethmoid, and sphenoid sinuses. In regards to eye lens and thyroid doses, DT results in 0.1 mGy and 0.2 mGy respectively, where CT results in 10-32 mGy to the eye lens, and 0.6-1 mGy to the thyroid. Combined with the higher sensitivity and specificity to radiography, DT of the sinuses is a prospective imaging tool for screening in radiosensitive populations.[36]

Imaging-wise, the parameters can be seen in Table 3. With a slightly higher dose, sinus tomosynthesis has increased sensitivity and specificity of the maxillary, frontal, ethmoid and sphenoid sinuses, and has been suggested as a screening tool to replace radiography. However, it is susceptible to motion artifacts,[37] and has limited literature available on the topic, with the most recent article being a pilot study published in 2013.[38] Despite its potential applications in radiosensitive populations, it has yet to influence clinical practice.

Table 3. *Standard Parameters for Sinus Tomosynthesis*[36-38]

Tube Voltage	Tube Current (mA)	Sweep Angle	Projections
80-200	1	40	60

Orthopaedic tomosynthesis: In orthopaedics, DT can more clearly define complex fractures and can rule out ambiguous cases, or monitor degenerative disease which can reduce the need for CT. In a clinical setting, as it is offered as an advanced modality option from major vendors, it could serve as a bridging modality to save both radiation and in-department time for the patients in radiographic examinations.[39] This is reflected in the cost, where studies have described lower per-patient diagnostic imaging costs upon implementation, as well as a reduced need for CT.[40]

The imaging parameters in orthopaedics vary with each region, where the standard sweep angle set would be around 40°. The kVp and mAs are dependent on the body region; for the wrist or foot, this would be 50-60 kVp and around 0.6 mA.[41-43]

CONCLUSION

Digital tomosynthesis is a promising imaging modality that acquires multiple low dose projections over a limited arc of the X-ray tube, and produces a stack of slices in the acquisition plane using image reconstruction. Through this, it provides depth resolution and reduces the degree of obscuration by overlying structures, improving the sensitivity compared to conventional radiography at a significantly lower dose to CT. Despite being prone to artefacts, it has been shown to be effective for surveillance and identification of occult fractures. Currently available as an add-on to conventional radiography equipment, DT has the potential to reduce the radiation burden, cost and time in department of patients who require continual imaging. However, large-scale studies demonstrating statistically significant results are required to validate its place as an intermediate modality in clinical practice.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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